existing systems in a service allocation. Ideally, all of the currently operating or proposed systems within the preferred frequency range of the new application will be studied to see if co-frequency sharing is technically feasible. These studies result in the development of sharing constraints that would have to be placed upon both the existing and the new services in order for all of them to operate in the same frequency band. In almost all cases, co-frequency operation of two different radio services will result in constraints being placed upon both services.

iv) Allocation changes. When the constraints are acceptabk to all services involved in the spectrum sharing study, and the technical studies are completed, an ITU Recommendation is adopted by the administrations that describes the sharing constraints placed on the new and existing systems. ITU Recommendations are used by the ITU World Radiocommunication Conferences (WRC) **as** technical input to effect changes to the International Table of Frequency Allocations and by administrations to coordinate the operations of their radiocommunications systems.

One of the positive aspects of the ITU process for new and modified spectrum allocations is the amount of detailed analysis that is conducted to evaluate the system sharing possibilities prior to allocation. The studies are carried out by technical experts from a number of administrations and the resulting ITU Recommendation has a high probability of being correct in its conclusions and having international acceptance of the technology and constraints before new systems are implemented. The tradeoff is that the ITU allocation process can take years to complete which creates a delay for international or regional deployment of new systems.

2. Domestic approach to spectrum allocations

The Commission's allocation process also allocates spectrum to services, not to systems. Since its allocation process is not system or technology specific, a competitive marketplace is fostered by the Commission. Either on its own, or in response to a petition from the public, the Commission issues a rulemaking proceeding to allocate spectrum, it studies the technical aspects of the proposed services competing for new allocations and, through a transparent regulatory process, it strikes a balance among the services in allocating spectrum. In many instances, the domestic spectrum allocations are similar to, if not the same as, those that are internationally or regionally allocated. In those instances, the Commission takes full advantage of the technical studies conducted in the ITU process that led to the international frequency allocations. To a great extent, therefore, the Commission does already group service allocations based on technical characteristics of in-band and adjacent band services.

In some instances, however, the domestic allocations are significantly different than the international or regional frequency allocations. In some cases, too, the international process has not been completed but the time is ripe to implement a new service in the U.S. In other cases, the desire to sell new equipment outside of the U S . may not exist or there may not be a requirement for international protection from interference. In these cases, the time associated with the domestic allocation process is the driving factor in the amount of lead-time that a new system would need for design and implementation. The lead-time includes the technical compatibility studies necessary to support the service allocation.

During the domestic allocation process, the technical specifics of a new system or technology usually are provided to the Commission in the form of a petition for service rulemaking or in the form of a system license application. In deciding which competing systems will operate in a particular allocation, the Commission evaluates the technical characteristics of the systems that propose to operate in the service allocation from a potential inter-service and inter-system interference standpoint. After it adopts the technical rules for a service, the operating constraints that would need to be accepted by all services in the allocation (and at times, in the adjacent allocation) are defined. At this stage, the Commission essentially determines the amount of technical flexibility a particular system or systems will have within the service allocation. The Commission also develops license conditions and operating provisions that are placed on the system authorization consistent with the service rules for the allocation. The sharing arrangements in several frequency allocations are described in Appendix A to provide examples of how grouping like users in certain allocations has led to competition within **a** service, technical flexibility and efficient use of the spectrum.

B. Findings and Conclusions

Interference control is complicated by the mismatch between technical characteristics of systems close in frequency. Authorization of technically compatible systems within international and domestic spectrum allocations will promote the systems' technical flexibility, efficient spectrum usage, and provide radiocommunication system manufacturers an opportunity to more readily deploy equipment throughout the U S and abroad. For services that are global in nature, where U.S. manufacturers desire to deploy equipment abroad, or where cross-border coordination of a system **is** necessary, the Coinmission has promoted the "zoning" approach to spectrum allocations internationally. Commission staff participates in the international allocations processes and study group activities. A review of several services in various exclusive and shared allocations in Appendix A reveals that the Commission, to a great extent, does already take a "zoning" approach to domestic spectrum allocations as well.

The zoning approach leads to fewer constraints on the systems operating in the exclusive or shared allocations which provides greater technical flexibility for the services to develop, grow and evolve. In some cases (e.g. fixed-satellite) coordinated approaches to spectrum access have been developed whereby a system may operate without coordination if it operates bebw an established interference threshold. In a few other instances, the Commission has taken an ad hoc approach to spectrum allocations. The tradeoff made by the Commission in order to provide for a new service was to add more constraints to the existing and new services in the allocation. As more radiocommunication systems serve end users directly, and as the density of the user population increases, it will become even more important for the Commission to group spectrum allocations based on mutually-compatible technical characteristics of the services.

C. Recommendations

The Commission has had success in its “zoning” approach to grouping together systems with similar technical characteristics. In this regard, the Commission has, to a significant extent, grouped allocations based on mutually-compatible technical characteristics. It should continue this policy with respect to allocation of spectrum for new uses and also consider creating incentives to evolve dissimilar uses to compatible groupings. In this vein, the Working Group recommends that the Commission:

> [1] continue to foster the “zoning” approach to spectrum allocations internationally and regionally. The Commission should continue to participate in the international spectrum allocation processes, working with other U.S. Government agencies, **U.S.** industry, and foreign administrations, to develop technical criteria for intrasystem and inter-system interference mitigation and spectrum sharing;
>
> **[2]** develop service rules for systems and authorize those systems to use the frequency allocations in a way that least constrains all users of the spectrum [domestic and international] thereby increasing system technical flexibility and spectrum efficiency; and
>
> **[3]** use its spectrum rulemakngs and service rules findings and conclusions, where appropriate, to support additional or modified international or regional frequency allocations in the ITU process.

VII. Receiver Standards/Guidelines

A. Background

For more than six decades, the Commission’s general policy for managing or eliminating interference has been to control transmission parameters, mostly power and height, hut sometimes antennas. For the most part, the earlier state of spectrum use and receivers allowed for such a general spectrum policy. Receiver quality, oftentimes, became an afterthought. When the need to evaluate interference at the receiver level does arise, the Commission either applies a set of worst case receiver parameters or uses general receiver characteristcs for its determinations. This policy is reasonable for a spectrum environment that processes numerous fixed and high power services and a limited number of mobile and low power services.

The transformation of the spectrum environment to more cellular-like usage, with lower power levels and mobile use, necessitates that the Commission revisit its general policy requirements. **As** interference issues become more complex and the number of users and emitters proliferates, the Working Group believes the Commission will need to address receiver interference concerns and specific receiver evaluation criteria. Further, consideration should be given to new and more novel approaches to spectrum access, usage, and management to include adaptive receivers and future advanced receivers capable of monitoring interference temperature **as** a spectrum policy.

As part of its assigned tasks, the Working Group considered the following receiver-related questions:

- Should the Commission promulgate rules on receiver standards or request that the telecommunications industries voluntarily establish receiver standards and/or guidelines?
- Should the Commission adopt minimum receiver performance standards and encourage the markets to build and deploy higher quality receivers above our minimum threshold?
- Should the Commission define a quality of service threshold based on operational requirements for each service?
- Should the Commission promote the development of receivers to foster the concept of interference temperature?

B. Discussion

From a simplistic and physical standpoint, any transmission facility requires a transmitter, a medium for transmission, and a receiver. Focus on receiver characteristics has not been high in past spectrum use concerns, hence, a shift in focus **is** in order. The Working Group believes that receiver reception factors, including sensitivity, selectivity, and interference tolerance, need to play a prominent role in spectrum policy.

The record, including a number of commenters to the Task Force's public notice (PN commenters)[76] and participants in the Working Group's public workshop supported the need for receiver standards, guidelines, or incentives to evaluate harmful interference. Both the PN commenters and the workshop participants assert that from a technical standpoint, interference acceptability and susceptibility, as well as increased spectrum efficiency, are highly dependent on the quality and sensitivity of the receiver used. Spectrum sharing feasibility studies are made easier if, at least, theminimum performance characteristics of receivers operating in a band are known. They noted, however, that unless the characteristics of the receiver can he dictated by the service provider (e.g. cellular telephones), the provider has no control over the quality of the receiver (e.g. broadcasters). The commenters further noted that rapidly advancing technology such **as** softwaredefined radio and adaptive receivers that can filter and excise interference effectively should be factored in spectrum policy considerations.[77]

The PN commenters **also** generally favored the development, adoption, and implementation of receiver standards/guidelines/incentives (receiver standards), or, in the alternative, minimum receiver performance requirements. Their views are

[76] ***See Public*** *Notice,* "Spectrum Policy Task Force Seeks Public Comment on Issues Related to Commission's Spectrum Policies," **DA** 02-I3 **II** (lune 6, 2002) (PN).

[77] Comments of HYPRES, Inc. at ***5***.

buttressed by those of the workshop participants held by the other three Spectrum Policy Task Force Working Groups.

On receiver standards, participating parties, both those favoring and those opposing Commission adoption of receiver standards or minimum receiver performance requirements, acknowledged that receiver performance characteristics are essential to interference evaluation, feasibility studies, and the design of new and improved systems.[78] The parties supporting Commission adoption of receiver standards or minimum receiver performance requirements indicated that receiver standards would promote spectrum sharing and system interoperability, and provide common performance values that all equipment manufacturers must meet.[79]

The opposing parties stated that receiver standards would stifle innovation and negate the natural progression of technology, could eliminate lowest cost receivers from the marketplace, and could force consumers to purchase higher priced receivers." They also pointed out that the rapidly changing technology landscape would result in receiver standards that would require constant Commission monitoring and maintenances' Even those parties opposing receiver standards, however, did support, in varying degrees, the adoption of minimum receiver performance requirements.

If adoption of either receiver standards or minimum receiver performance requirements **is** contemplated, working group participants suggested consideration of the following parameters. They include selectivity, susceptibility, dynamic range, local oscillator phase noise, data throughput, unwanted emissions, various carrier-to-noise or carrier-to-interference metrics, equipment performance labeling, tuned filtering, and interference suppression and rejection.[82]

Parties supporting receiver standards believe that long-term protection of legacy receivers stifles innovation and delays public acceptance and purchase of new technology and that legacy receivers should not receive long-term or indefinite protection." **A** few commenters suggested that a date-certain protection sunset for legacy receivers, based on equipment life cycles and amortization schedules, should he

[78] Comments of Aeronautical Radio, Inc. at 4; Comments of Cingular Wireless LLC at 52; and, Comments of National Public Radio at 17.
[79] Late-Filed Comments of IEEE 802.18 Radio Regulatory Technical Advisory Group, IEEE 802.11, 802.15, and 802.16 Working Groups, and the IEEE 802 Metropolitan Network Standards Committee at 10; **and** Comments of Public Safety Wireless Network Program at 11.
[80] Comments of BellSouth Corporation at 12; Comments of Charles L. Jackson at 3; Comments of Nortel Networks at 6; and Comments **of** Wayne Longman at 19.
[81] Comments of BellSouth Corporation at 12.
[82] Late-Filed Comments of IEEE 802.18 Radio Regulatory Technical Advisory Group, IEEE 802.11, 802.15, and 802.16 Working Groups, and the IEEE 802 Metropolitan Network Standards Committee at 10; Comments of **Dr.** William C. Y. Lee, LinkAir Communications, Inc. at **4**; and Comments of Nortel Networks at 8.
[83] Reply Comments of American Mobile Telecommunications Association at 8; and Comments of Marlon K. Schafer at 5.

imposed.[84] Others suggested that receiver certifications he timelimited (perhaps five to seven years), and that at the end of the certification period, the receiver manufacturer should be required to cease manufacture of the obsolete equipment? Virtually all public participants agreed that there should be differing receiver standards among various radio services, and that services could be grouped by spectral characteristics, the application using the service, the bandwidth required by the application, and the application's potential for spectrum efficiency and sharing.[86]

in addition to the above, commenters specifically recommended the following:

- The Commission should initiate an evaluation of the performance characteristics of current receivers, particularly interference immunity, in order to provide an accurate assessment of the current operating environment on which to base new **standardslguidelineslincentives** or minimum receiver performance requirements.[87]
- The Commission should convene an industry panel to devise a plan for the resale, trade-in, and recycling of legacy receivers to stimulate public acceptance of new technologies!'
- The Commission should require product labeling that contains evaluation of product performance against objective performance benchmarks.[89]

C. Recommendations

The public record voiced a need for further action on receiver standards by the Commission. **As** discussed above, the Working Group has been considering the concept of interference temperature as another means of improving spectrum access and the creation of receivers capable of monitoring interference temperature needs to follow.

1. The Working Group recommends that the Commission initiate a ***Notice*** *of Inquiry* (NOI) addressing the adoption and implementation of either receiver standards/guidelines/incentives or minimum receiver performance requirements in the very near future. It suggests that the NOI seek comments on: how to characterize the current receiver environment; whether the Commission has the authority to issue receiver standards; what minimum performance parameters need to be considered; how to group differing receiver standards for different radio services; how recent receiver

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84 Late-Filed Comments **of** IEEE 802.18 Radio Regulatory Technical Advisory Group, IEEE 802.11, 802.15, and 802.16 Working Groups, **and** the IEEE 802 Metropolitan Network Standards Committee at 11.
85 Comments of David R. Hughes, Old Colorado City Communications Company at 3.
86 Comments of Ericsson Inc. at **7**; Late-Filed Comments of IEEE 802.18 Radio Regulatory Technical Advisory Group, IEEE 802.11,802.15,and 802.16 Working Groups, and the IEEE 802 Metropolitan Network Standards Commitlee at 11; Comments of Dr. William C. Y. Lee, LinkAir Communications, Inc. at **4;** Comments of Marlon K. Schafer at ***5;*** and Comments of Public Safety Wireless Network Program at 11.
87 Comments of National Public Radio at 21
88 Comments of Citizens Media Corp/Allston-Brighton Free Radio at 13.
89 Comments of National Public Radio at 19.

developments such **as** softwaredefined radios could decrease current interference constraints; the level of protection and the length of time protection **is** afforded to legacy receivers, particularly those deployed by Public Safety and rural users; how receiver standards, if adopted, might stifle innovation; and how to contend with the possible potential negative effect of eliminating the lowest cost receivers from the marketplace.

2. The Working Group also recommends that the Commission pursue a detailed study of the advantages and disadvantages of using interference temperature as a means of addressing spectrum access and interference acceptance in the future. Future studies should include a comprehensive assessment of the interference(noise) temperature for all regions of the country. This assessment necessarily would be time consuming and expensive. While resource intensive, such an assessment could reap enormous spectrum access benefits and improvements for the telecom industry. **As** such, the telecom industry may consider funding or assisting in the funding of the assessment. If this interference temperature assessment **is** successful, the Commission should take prompt regulatory action to mcorporate the use of interference temperature as part of its future spectrum policy. In this regard, for those receivers that the Commission might choose to be subjected to interference temperature limits, the Working Group recommends that the Commission either propose performance requirements for interference temperature capable receivers or request that the industry adopt and implement such standards.

3. Aside from the NOI and unrelated to interference temperature, the Working Group recommends that the FCC either commission a study group or issue a contracting proposal for an evaluation of the performance characteristics of current receivers to provide a better assessment of the current interference environment. This assessment could be used to improve the Commission's spectrum allotment policies or assist in the future development of receiver standards.

4. The Working Group also suggests that parallel to the NOI, the Commission convene industry committees to seek the creation of voluntary industry standards, guidelines or labeling for advancing receiver standards. If consensus is reached, the Commission could initiate a rulemaking to embrace the standards, either through a labeling or certification program or **as** part of the Commission's Rules.

5. The Working Group further suggests that the Commission urge the telecommunications industries to devise a plan to expedite legacy receiver replacement, perhaps by implementing the resale/trade-in/recycle plan suggested by the public. In the alternative, as an incentive to the deployment of more advanced receivers and the replacement of legacy receivers, the Commission could allow additional flexibility or increased power for those services or users deploying more advanced receivers.

In short, the time for intensive study and review of both current and future receivers is now.

VIII. Communications with the Public on Interference Issues

A. Introduction

The ability of the new radio-based technologies to become realities in the marketplace depends to an important extent on the terms and descriptions of interference. Disputes as to what may or may not constitute an effect of one service on another has been made at times more difficult to resolve because of informal and inconsistent language describing interference and its impact. In addition, entrepreneurs and others seeking to implement new systems or improvements to existing systems have found it difficult to determine which rules are appropriate candidates for revision and what the changes would be. Beyond the regulatory language and rules addressing interference, the actual experience of licensees and others engaged in the process of fielding new or changed communications systems constitutes an important asset that should be more easily available to others seeking to establish radio-based services.

B. Discussion

The Working Group sees a need to consider several focused efforts to make the Commission's interference rules, policies, processes and available tools more transparent, that is, more comprehensible, consistent, and easy to use.

1. Harmonizing Interference Language (Technical Terms and Units)

The rules governing interference for the wide variety of radio-based communications regulated by the FCC today are the result of a process that has evolved over time and that addresses the specific services involved and circumstances of the potential interference situations. Historically, the Commission has developed the technical interference criteria contained in the various parts of its rules on an industry by industry and service by service basis, responding to the particular situation presented by those seeking to establish new services and reacting to the concerns of potentially affected existing services. Each industry and to some extent each service within an industry has its own engineering "culture," that is, a body of conventional technical practices and terminology widely used by planners and licensees within that particular service.

The resulting treatment of interference for the ***ad hoc*** situations presented to the FCC has led to the successful implementation of a wide variety of radio-based systems in operation today. The existing language, however, addressing interference is highly diverse and not always consistent. This resulting body of interference language has become a daunting challenge for those seeking to learn how they should consider the lessons of the past in order to plan for the future.

The interference management rules governing **a** particular radio service have been adopted in a public proceeding based on a record containing technical material submitted by stakeholders of the pertinent industry and other potentially affected parties. The specific criteria are often the result a compromise between competing goals of a satisfactory level of performance for the licensees and an acceptable level of impact on others in nearby frequency bands or geographic locations. The circumstances for the determination of each new service are frequently unique to the situation brought to the FCC by petitioners seeking to alter the status quo in order to permit them to operate under the revised rules. The language addressing interference differs from service to service and reflects the nature of the service, the sharing situation, and the expectations of the community.

The technical interference criteria contained in the Commission's rules are fundamentally based on considerations of power and propagation in broad frequency classifications (*i.e.* high frequency (HF), very high frequency (VHF), ultra high frequency (UHF), *etc.*) The criteria in the rules also reflect operating considerations, such as whether the service **is** a fixed or mobile service. For example, interference criteria for mobile units generally incorporate an additional margin to account for signal fading resulting from the motion of the mobile unit. The technical criteria also reflect an expectation of the quality of service that will be demanded by licensees. Some services can be completely functional in the presence of a low level of interference, whereas users of other services, particularly public safety services, subscriber services, and broadcast services, have an expectation of a greater freedom from interference.

Even within a particular service the language describing interference may be variable and inconsistent. For example, rules defining interference levels may have initially been established for analog systems and not comparably revised for the advent of digital systems. Over time estimated propagation distances and hence expectations of impact may have changed due to the widespread availability of more accurate propagation models. In addition newly implemented services similar to an earlier generation of systems may have the expectation of more technical freedom and flexibility and hence have simpler interference rules.

The wide differences in approaches to interference management in the FCC's rules also shows up in the technical parameters that are used **to** describe performance and impact. The differences in units, methods and metrics for interference management that exist between the various services can be categorized **as** major differences, minor differences and inconsistencies. The major differences arise when the service quality or reliability goals for the services differ, or when concerns for administrative efficiency outweigh those **for** more accurate technical assignment (*e.g.,* if a large number of license application filings **is** expected). **A** different approach may also be appropriate where a service is presumed to be interferencelimited rather than noise-limited under the expected operating radio frequency environment. Another factor resulting in major differences **is** whether the service is structured as a broadband or narrowhand service. Broadband services must rely far more heavily on frequency use coordination between licensees to manage interference than do narrowband services. **As** a result, FCC technical rules for broadband services focus on signal coverage parameters rather than desired-to-undesired signal ratios. Broadband services **also** incorporate technical flexibility as well as service flexibility, which may limit the usefulness of such ratios.

Minor differences arise when services utilize a similar approach (*e.g.*, minimum DIU ratio), but employ different propagation models for the same general frequency range. In the UHF range, the Commission has approved or required the use of methods derived from three somewhat different sets of empirically derived field strength curves—R6602, Carey (ITU) and Okimura—for essentially similar services. For example, the historical and current practice is to use Carey-based tools for CMRS systems licensed under Part 22 and methods based on R6602 for similar CMRS licensed under Part 90. Furthermore, Okimura based criteria are used for other service types of stations, such as for paging systems as opposed to two-way radios for both Part 22 and Part 90. Finally, inconsistencies may appear to exist where the FCC's rules contain different expressions of engineering units that have been derived from different considerations of power, relative power, or electric field. These differences reflect the different approaches to describing and characterizing interference and its impact that are peculiar to the specific situation such as for broadcast or mobile services, for example, DIU and C/I, or dBμ and dBμV/m.

When the FCC makes a determination to implement a new or changed service, it correctly focuses on the interference situations presented by the parties and also on the context of the existing rules and services for impacted services. The resulting record of interference language in the rules today, however, for the many FCC-regulated services has become unnecessarily varied and is not always consistent—service to service. It has not been a focused goal of the FCC to treat its own rules objectively as a source of information on approaches to interference—its definition, management and control. Although the record stands as an authoritative body of rules on interference, it appears that these interference rules could he made more user-friendly; and it may be an appropriate and useful expenditure of the FCC's resources to review its rules on interference with the objective of harmonizing the language of interference to the extent possible. While important distinctions should always be made, there is a benefit to using more uniform language when describing interference and its impact. It is noted that the process of biennially reviewing and streamlining the FCC's rules is an existing process that could be tasked with an additional goal of harmonizing the interference rules. Where possible, consistencies and inconsistencies in the technical parameters and units could be highlighted and explained. In addition the FCC should be conscious of the international environment for the language describing interference and seek to harmonize our descriptions with those of other administrations.

2. Ensuring Consistent and Appropriate Use of Interference Language (Nom Technical Qualifiers)

The same variability in language on interference that pervades the FCC's rulemaking proceedings and the resulting rules also gives rise to inconsistent discussion of the impact of interference from a non-technical perspective. While in principle technical terminology may be made more objectively uniform, where possible, especially if the technical assumptions and conditions are specified, the terminology addressing the resulting impact of signal degradation on a user or subscriber may he regarded as subjective.

In its June **2002** public notice, the SPTF signaled its openness on the interest in, or need for, new definitions of "interference" and "harmful interference." In response, the majority of parties commenting on this issue argue that no change in the definitions is needed. Those arguing that the current definitions are too subjective and open to interpretation are outnumbered by those who believe that formal revision of the definitions would lead to constraints on technical innovation and to more interference disputes. However, a consensus among both sets of commenters is that the ***usage*** of these terms by the FCC is unclear.

Commenters on both sides raise issues with the current definitions and their use in the FCC's rules. They argue that the use of the terms "interference" and "harmful interference" is too informal and inconsistent. Sprint asserts that "there can be no serious dispute over the need for the Commission to confirm and clarify the scope of harmful interference, if not codify those clarifications in the rules or in notes to the rules.'" The Information Technology Industry Council recommends, "in order for the Commission to be able to solve actual harmful interference situations, the Commission needs to better define the distinction between interference and harmful interference.'" PanAmSat's comments propose an alternative to redefining the terms: "The Commission should not redefine the terms "interference" and "harmful interference," or attempt to quantify what constitutes harmful interference, but should clarify the use of those terms in its rules.'[92]

Bringing in the international perspective, the Satellite Industry Association **(SIA)** elaborates on the appropriate use of the terms "harmful," "accepted," and "permissible" interference in the context of adopting sharing criteria:

> "The definitions for 'interference' and 'harmful nterference' have been established and agreed to within the ITU for some time. In addition, there are also established definitions for 'permissible interference' and 'accepted interference.'. **..** It is not clear what purpose would be served by redefining any of these terms. Instead the Commission should make clear the use of these terms in its regulations. Harmful interference is an extreme level of interference that is rarely seen when properly functioning radio equipment is used in a frequency band by services or systems that operate on a co-primary basis. At the same time, it is clear that just because interference between such services or systems in a band does not rise to the high level of 'harmful interference' it cannot be reasonably concluded that the interference is subjectively acceptable or tolerable to the victim service or users. **As** a result, the Commission's, and even the ITU's, attempts to quantify the level that constitutes harmful interference are really not a useful exercise. The key is to find ways to ensure that the level of interference **...** is not and will not be at a level that will result in the interruption or degradation of one of the services using the band. Therefore, the level of interference that is appropriate for allowance from

[90] Sprint Comments at 12.
[91] Information Technology **Industry** Council Comments at **9.**
[92] PanAmSat **Reply** Comments at 2.

> one service into another is always less than harmful interference. That is where the term acceptable interference should be used ... For the Commission's purposes, the object of most spectrum sharing rulemaking proceedings – at least those not involving assessment of interference to a safety service – should be to identify the level of permissible interference... [T]he Commission should, when adopting sharing criteria, use the terms permissible or acceptable interference.'"

Although distinctions between of levels of interference will continue to be discussed, the Working Group believes that the qualifiers describing the impact of the interference should be more consistent and appropriate, as the FCC discusses its interference decisions and describes its interference rules.

A systematic review of the interference rules and definitions would be required to ensure such consistency. The interference definitions scattered throughout the rule parts may be standardized to reflect the language of the definitions from Section 2.1 of the FCC's rules or the ITU Radio Regulations. In addition, undefined qualifiers such as "objectionable" may be replaced with standard qualifiers or redefined to remove ambiguity and subjectivity. Instances of the terms "harmful," "accepted," and "permissible" interference could be reviewed to ensure that their use matches the meanings of their respective definitions. The FCC may also seek to add qualifiers where such an addition may usefully clarify the meanng.

Short of redefining interference broadly, the consistent and appropriate use of qualifiers would remove some ambiguity for licensees, applicants, industry, and the general public who are trying to comply with interference rules. The Working Group believes that clarifying the use of interference qualifiers and ensuring consistency is a suitable compromise between the extremes of redefining interference and taking no action with the definitions.

3. Facilitating Access to the FCC's Rules on Interference

Title 47 of the Code of Federal Regulations contains the rules governing interference for FCC-regulated services. These rules however are spread throughout a number of different rule parts comprising five volumes and over 3600 pages. Beyond the problems cited in the preceding paragraphs on the technical and non-technical language on the definition and management of interference, the body of regulations governing interference for all services is vast in scope and voluminous in size. Moreover, the actual interference rules themselves are not easily identified and isolated in the context of all the rules governing a particular service. For example, for certain services interference may be indirectly governed by specifying minimum separation distances or limitations on transmitter power and antenna height—without ever mentioning the word "interference" or referring to levels of interference.

[93] Satellite Industry Association Comments at 10-11.

In order to assist those seeking to understand the interference determinations for the existing services, it seems appropriate for the FCC to provide a roadmap or directed guide that would facilitate access to rules governing interference for any regulated service. Providing the interference rules for all services in all frequency bands regulated hy the FCC in ***a consolidated*** *summary* may be helpful to licensees when evaluating actual interference from other users or determining their own requirements.

Rules governing interference protection may include, depending on the service, a combination of service contours, interference contours, emission masks, transient frequency behavior, directional antennas, out-of-band emission limits, power limit, antenna height restrictions, and other criteria. Procedures to measure interferencerelated parameters may also be contained in the rules. For example, certain rules may specify technical relationships and limitations by means of equations, propagation models, or measurement procedures. The direct availability of the rules governing interference may help to more quickly resolve interference disputes or determine the potential for interference and could service as an aid to frequency coordination. A consolidated summary may also prove useful to licensees who may not know exactly which services are in shared or adjacent bands or the corresponding FCC rules that regulate these services.

There are also additional interference requirements that may not he contained in the section of **47** CFR that contain a given service's technical rules. In **47** CFR Parts 1 and **2** certain requirements and procedures are specified that pertain to a number of services in various rule parts. For example, Section 1.924 of the rules contains procedures and associated field strength limits licensees should be aware of to protect radio astronomy sites, FCC field offices and sensitive Government facilities. Licensees may not be aware of such requirements because the governing rules are not directly included in their services' rule parts. In addition, Section 1.923 states that some channel assignments and/or usage may be subject to provisions and requirements of treaties and other international agreements between the United States and Canada and Mexico. This general requirement is more typically contained in **47** CFR Part **1** rather than in the applicable rule part. (The treaties and agreements are not actually contained in the rules. Certain agreements with Canada and Mexico are contained within the International Bureau's web site http://www.fcc.gov/ib/sand/agree/. This is not an inclusive list however, as many agreements were approved decades ago[94].)

An analogy to a consolidated summary of rules governing interference may be made to OET Bulletin 65, which contains the general rules on limits for the absorption of electromagnetic radiation by humans. This bulletin, and its many supplements and annexes, may be analogous to a summary of interference rules, but on a much smaller

[94] For **example,** ***see*** **Agreement Concerning** ***the*** **Coordination** ***and Use of Radio*** **Frequencies** ***Above Thirty Megacycles per Second, with*** **Annex,** ***as amended*****, Exchange** of **Notes at Ottawa, Canada, October 24,** 1962, **Entered into force October 24, 1962. See** *also* **USA:** *Treaties and Other International Acts* **Series (TIAS) 5205; CAN:** *Canada Treaty* ***Series*** **(CTS) 1962 No. 15; Agreement** ***Revision Technical*** **Annex** ***lo the*** **Agreement** ***of October 24,*** *1962* (TIAS 5205/CTS **1962** No. 15) **Effected** by **Exchange of Notes at Ottawa, Canada, June** 16 and 24, 1965, **Entered into force June 24, 1965.** USA:TIAS 5833/CAN: CTS **1962 No. 15, as** amended June 24, 1965.

scale, in that it addresses all FCC-regulated services in specifying acceptable measurement procedures for compliance with the standard for absorption of radiation.

A single document containing the consolidated summary of interference rules would be physically large, and maintaining its currency could require a considerable expenditure of time and other resources. The FCC is necessarily continually in the process of revising its existing rules and establishing new ones, and the potential exists for differences to develop between the rules as contained in 47 CFR and those as summarized in a separate document. Therefore, a practical means to maintain a consolidated summary of the interference rules may be to establish a web site that provides links to the appropriate sections of the most recent version **47** CFR and other useful information such as access to propagation models in current use. **An** electronic implementation of the consolidated summary of the interference rules comprising a series of links to the most recent version of the Rules may be the most efficient way to keep the summary up to date. For instance, the United States Government Printing Office periodically updates 47 CFR and houses the single source the FCC rules at its web site, http://www.access.ppo.gov/ecfr/.

4. Facilitating Access to Successful Practices for Interference Resolution

In an ideal world new services following the technical specifications and the service rules developed through the FCC's processes and promulgated in 47 Code of Federal Regulations (Telecommunications) would be designed, licensed, and implemented, without interference to existing licensees in neighboring frequency bands and geographic areas. In reality, however, practical systems are developed and fielded with an appreciation of the fact that transmissions from actual equipment in operation may be received by neighboring licensees for a variety of reasons including the non-ideal nature of transmitters, antennas, and receivers, the details of their relative positioning, and the statistical nature of electromagnetic propagation. Increasingly, the FCC has come to depend on the efforts of new and existing licensees and even third parties to make practical systems function together without improperly affecting each other, especially in shared bands. Indeed, the FCC has long depended on the efforts of third parties such as frequency coordinators for certain bands to assist new entrants by selecting appropriate frequencies and locations using detailed and complete data bases of licensee information including the technical specifications and actual locations of the transmitters and receivers. Fixed microwave facilities, private mobile radio services, and satellite earth stations are examples. Importantly, the FCC in permitting increasingly flexible services such as Personal Communications Services has come to assume that licensees or their agents will seek to coordinate their system implementations and subsequent changes directly with each other rather than seek FCC intervention. PCS licensees have strongly supported this approach and have made it work.

Realizing the importance of the efforts of licensees themselves and of third parties to supplement the effectiveness of defined interference limitations and the technical and operational service rules, the Spectrum Policy Task Force raised the question of the desirability of facilitating privately negotiated solutions to interference problems. Such an approach could bring to the process of resolution of interference – from both a planning and an operational perspective — economic considerations of the impact of interference. Many commenters viewed positively efforts by the Commission to support such direct negotiated solutions. **A** general sense from the comments is that if private parties have sufficient information at their disposal, and if the Commission's rules regarding licensee rights with respect to possible interference are clear, the preferred approach **is** to try to resolve interference problems directly among the affected parties. Only if such efforts fail should the interference problem be referred to the Commission for resolution. Parties feel that private negotiations will lead, in **most** cases, to a much faster and more acceptable resolution of interference problems than using the Commission's regulatory processes.

In view of the fact that the total compendium of the FCC's rules in 47 CFR is not a complete handbook on how to implement practical communications systems, the experience of licensees and third parties across the several communications communities regulated by the FCC should be viewed as a valuable asset that could be used more widely. Accordingly, a "handbook" identifying successful practices, standards associations, key technical bulletins from the industry associations, and other aids in the resolution of interference could supplement the effectiveness of 47 CFR for interference management. Such a gathering of successful practices, a "best practices handbook," would be especially useful to those outside the existing communications communities seeking access to the electromagnetic spectrum for the first time with potentially innovative technologies. **A** "best practices handbook" for nterference management would be a compendium of available information broadly related to the subject of interference management. Such a compendium need not be an actual physical document and could be realized as a web site containing important documents and standards addressing interference and links to other sites with relevant information on interference management for specific licensee communities. In this way, the information could be continuously and efficiently updated, and users could be assured that they were accessing the latest available information. Included in such a handbook could be such material as current industry guidelines used to coordinate spectrum use and manage co-channel and adjacent-channel interference problems for each service or group of services, examples of successful interference management negotiations, a list of steps parties should take to resolve interference problems; a list of steps parties could take to demonstrate that a proposed service will not pose undue interference on incumbent licensees, relevant technical bulletins issued by the FCC or technical standards bodies, a **list** of frequency coordination organizations, including links to their web sites, and a discussion of the FCC's licensee databases, including general instructions on how to conduct searches for co-channel licensees, for example, within a specified geographic area.

The handbook could be a vehicle to assemble and organize relevant interference management information in one virtual location to assist parties to help themselves to resolve problems independently, without direct FCC involvement. An example of the successful use of an actual best practices guide is a document developed in 2000 by several trade associations, an equipment manufacturer, and a wireless service provider to suggest ways to reduce or eliminate interference between public safety and CMRS radio systems. Subsequently, the Commission issued a News Release describing the guide and providing a copy of the full publication by mans of a link to an electronic version. It is anticipated that a best practice handbook for interference management would include a link to this guide as well as any similar guides that may be relevant to interference management.

C. Recommendations

The Working Group recognizes the importance of the public's access to comprehensible and useful information and practices on interference management and has the following recommendations that address broadly (1) the language of interference and (2) the rules and practices governing interference management:

- Initiate a review and revision of the FCC's rules, possibly in conjunction with the existing biennial reviews, with the goals of
  - Harmonizing interference language, focusing on technical terms and units, and
  - Ensuring consistent and appropriate use of interference language, focusing on uon-technical qualifiers.

- Organize and make public in documentation or at a web site, for the purpose of facilitating public access, a comprehensive and authoritative gathering of
  - The rules on interference for all the FCC's radio-based services and
  - The practices and procedures for interference resolution.

IX. Acknowledgements

The members of the Interference Protection Working Group wish to thank the participants in the public workshop on Interference Protection held on August **2,** 2002. The wide-ranging views of these professionals reflect the deep experience of a diversity of communications communities and disciplines and have significantly informed the public discussion on the subject of interference.

APPENDIX A

Allocating Spectrum to Radiocommunication Services that are Grouped Together by their Similar Technical Characteristics

Exclusive Use of Service Allocations Based on Technical Characteristics

Radiocommunication services are able to operate in adjacent frequency bands through the use of power limits, out-of-band emission limits, and use of receivers that are able to filter out unacceptable interference from systems operating in adjacent frequency allocations. Other portions of this report focus on the specific technical characteristics that can be used for groupings or "zonin ·· based on a system's sensitivity to interference and how in-band signals are transmitted! We focus here on the services that are allocated the same spectrum and have regulatory status in that spectrum.

Terrestrial Broadcasting Services

AM radio stations operate in the Broadcasting Service allocations from 535 kHz - 1705 kHz. AM stations are assigned frequencies on a non-interfering basis using desired-to-undesired signal ratios and power limits. There are four classes of AM stations with permissible powers between 0.25 kW and 50 kW. FM radio stations operate in the Broadcasting Service allocation from **88** -108 MHz. The Commission authorizes commercial and noncommercial educational (NCE) full-service stations, and low power FM (LPFM), FM translator, and FM booster secondary stations in this exclusive spectrum. Only commercial FM stations **(92.1** MHZ to 107.9 MHZ) are assigned channels based on geographic allotments. Commercial FM stations are assigned these channels using minimum distance separation requirements that are based on desired-to-undesired signal ratios. There are seven classes of commercial FM stations (Class A, B1, B, C3, C2, C1, C) that are based on power (maximum permissible ERP is 100 kW) and antenna height (maximum permissible antenna HAAT is 600 meters) requirements. NCE FM stations are assigned channels on a non-interfering basis using desired-to-undesired signal ratios and power and antenna height limits. Based on power and antenna height authorized, NCE FM stations are assigned the same classes as commercial FM stations. There are two classes **of** LPFM stations (LP100 - 100 watts max ERP and 30 meters max antenna HAAT, LP10 - 10 watts max ERP and 30 meters max antenna HAAT) which are assigned channels using minimum distance separation requirements that are based on desired-to-undesired signal ratios. FM translator and FM booster stations are assigned channels on a non-interfering basis using desired-to-undesired signal ratios. AM and FM radio technology has substantially evolved over several decades. The exclusive Broadcasting allocations have provided this service the opportunity to explore ways to overlay digital radio technology in the same allocations (e.g. In-band, On Channel (IBOC) and In-band, Adjacent Channel (IBAC)). The constraints on the development of the digital systems have been inter-system related, not inter-service

[95] These two areas are evaluated in other sections of this report on "Including receiver tolerances in the regulations" and "Enhancing transmitter interference control," respectively.

related. The addition of inter-service constraints would likely have resulted in further difficulties in developing the digital overlay techniques that are now being evaluated.

Broadcast television is allocated spectrum from **54** MHz to 806 MHz. The Commission authorizes full-service commercial and noncommercial TV broadcast stations, and low power TV (LPTV), TV translator, and TV booster secondary stations throughout the allocation. Only full-service commercial and noncommercial FM stations are assigned based on geographic allotments made to communities using minimum distance separation requirements that are based on desired-to-undesired signal ratios. Secondary LPTV, TV translator, and TV booster stations are assigned, for the most part, on a non-interfering basis using desired-to-undesired signal ratios. Broadcast **TV** has exclusive use of the Broadcasting Service allocation on channels 2 through 13 (54 MHZ to 216 MHZ) and channels 21 to 69 (512 MHZ to 806 MHZ), but must share spectrum on channels 14 through 20 (470 MHZ to 512 MHZ) with Public Mobile Services (Part 22) and Private Land Mobile Radio Services (Part 90). Broadcast auxiliary services also operate in the shared spectrum and are assigned frequencies on a non-interfering basis. The Commission continues to encourage Digital Television implementation in the exclusive Broadcasting Service allocation. The exclusive allocation has provided for digital television service rules that are less constrained than if the allocation were shared with other services.

Terrestrial Mobile Services

Mobile services are provided terrestrially in a wide variety of frequency hands, predominantly less than *2* GHz, allocated to the Mobile (and frequently Fixed) Services, for a wide variety of private and commercial purposes. The earliest mobile services were in support of public safety purposes and eventually evolved into the larger class of non-commercial, land mobile radio services, which today are usually not inter-connected to the public switched telephone network. This larger class is dominated by private land mobile services (Part 90), but also includes aviation (Part 80) and maritime (Part 87) services. Private land mobile radio services, which support the radio needs of private companies, as opposed to companies that offer communications services to the public, and other organizations such as state and local governments, generally share the frequencies that they occupy below 470 MHz. They have non-exclusive access to the channels through coordinators and may be assigned to timeshare certain channels that are being used by other private users. For private services that use hands generally above 800 MHz, access to the spectrum *is* on an exclusive, "first come, first sewed" basis. Licenses for these services are generally site-based, that is, an applicant is granted the exclusive right to use the certain frequencies within an area determined by a base station location and a radius of operations for the mobile units. Other channels in the same geographic area may he assigned to other applicants through a coordinator for the services who maintains a database of the assignments. The same channel may be reused by another licensee, if it is determined that the inter-site distance is sufficiently large so that the services would not interfere with each other; for example, 70 miles separation is required for private services at 800 MHz, because of the high power of the base station transmitters.

Commercial mobile radio services, on the other hand, are generally provided on a for-profit basis and offer inter-connection to the public switched telephone network (PSTN). The commercial mobile services of today have evolved from efforts to extend the PSTN to people in moving vehicles allowing them to talk to land-based telephone subscribers. The cellular concept evolved in a major movement away from the large separation distances required by private mobile services, which serve their mobiles with a single, high-powered transmitter. This concept involved the reuse of the same channels through smaller radius cells with lower-powered base stations and mobiles. The first important commercial radio service was cellular radiotelephone service. Starting in the 1980s, the FCC assigned equal amounts of spectrum on an exclusive basis to two cellular systems in each geographic area. These early assignments established a duopoly of carriers and involved licensing the single wireline common carrier in each area, but then making another license available, through administrative hearings and, later, lotteries. The two cellular providers were to compete in their offerings of cellular service to the public and initially used the same mandated analog technical standard developed by the industry and placed into the rules by the FCC. The rules for the exclusive use by the licensees included the identification of separate hands for the two competing entities, power and height standards, and emission limitations for the base station and mobile unit transmitters. These limitations were largely to assure that the cellular concept was implemented rather than the earlier concept of higher power base stations serving large areas. In order to protect other cellular licensees on the same bands, but in adjacent geographic **areas,** the licensees were permitted direct coordination with their neighbors in order to assure that the channels selected by the neighboring cellular licensees would not cause interference.

In its first major move to establish technical flexibility, the FCC in the late 1980s relaxed the rules for the cellular radiotelephone service and permitted the licensees the use of technologies alternative to the analog standard. (Although alternative technologies such **as** digital transmission techniques were permitted, the carriers were required to maintain a level of analog service in order to keep open the option of a nation-wide common standard. The FCC **is** currently considering the removal of this analog requirement.) By giving the cellular licensees the flexibility to use aiternative transmission standads, the **FCC** enabled the move to digital mobile services. The FCC encouraged the cellular industry to act on its own and declined to participate in the industry standard-setting process to develop alternative digital standards, allowing the industry to determine its own best standards to best serve its business concept of service to the public. Out of this process digital mobile systems were developed and fielded for next-generation Time Division Multiple Access (TDMA) and Frequency Division Multiple Access (CDMA) systems. The CDMA standards developed in this process have evolved become the basis for the advanced communications services being considered for much of the world today. In addition to this technical flexibility for the cellular service, the FCC also granted service flexibility by facilitating other uses of the cellular frequencies than for the mobile service. Fixed services may he offered by the licensee. Data services, permitting early access to computer networks, were also enabled for the mobile user through the use of cellular-delivered, packet-data (CDPD) service. The freedom given to the exclusive licensees of the cellular frequency bands for flexible use of alternative digital technical systems and of alternative service offerings is limited by the requirement that other cellular operators not experience interference to their services.

In contrast to the cellular service, which started out with a detailed technical standard for a specific and well-defined concept **of** mobile service, the Personal Communications Services (PCS) at 1850-1990MHz was conceived from its beginning on the basis of technical flexibility to the licensee to choose the transmission standard that would best achieve the licensee's own concept of service. The purpose of the service was left to the licensee and was not specified in the minimal regulations, but only had to be consistent with the frequency allocation of Mobile or Fixed Services. The sizes of the spectrum blocks were sufficiently large to permit the licensees to subdivide the frequencies in order to offer alternative services. PCS licenses were assigned by competitive bidding, which was authorized by Congress in 1993. Accordingly, the licenses went to the highest bidder, thus allowing exclusive use ofthe spectrum under a flexible regime that would allow the licensee to respond to the market demands for service. Changes in the marketplace for communications services could in principle be undertaken without going to the FCC to initiate a rulemaking to implement new technical or service rules. The PCS technical rules specified no standard for channelization or for transmission and only gave height and power and emission limitations for the base stations and a maximum field strength to be maintained at the boundary of the service area. This field strength level could be renegotiated by the neighboring licensees. Within the licensee's service area, the licensee is free to use the technology of **its** choice to offer the service it deems appropriate, consistent with the few limitations that were imposed. Fewer constraints on the terrestrial mobile (and fixed) services **led** to greater technical flexibility within the service. The Commission is now considering how to implement 3rd Generation mobile services where even more technical flexibility is envisioned.

Satellite Services

Satellite systems are used to provide fixed, mobile, broadcasting and other types of commercial services. The antenna patterns of satellites (international and domestic) generally overlap each other in the same geographic service area. The isolation among the satellite systems comes from orbital location separation, antenna beam separation, frequency assignment separation, or a combination of these. We evaluate these concepts and how they have been applied by the Commission to services that have similar technical characteristics, In many instances, satellite services are grouped together based on their similar technical characteristics. Many of the intraservice coordination mechanisms described helow result from such groupings.

Fixed Satellite Service (FSS) - Geostationary(GSO/ FSS) sharing. GSO/GSO FSS sharing has been accomplished through orbital arc separation and the management of noise temperature (noise power) Contributions from other GSO FSS networks. First, the amount of orbital arc separation between GSO FSS satellites was derived from extensive studies based on analysis of management of noise temperature from contributions of adjacent systems in the GSO arc. The Commksion has adopted rules requiring an orbital separation of 2 degrees (2-degree spacing) for GSO FSS systems sharing the same spectrum and serving the U.S. This has provided for closer orbital spacing than generally used internationally and "packed" the GSO arc over the U.S. more densely. This has led to a rather competitive GSO **FSS** marketplace in the U.S. However, under this condition GSO systems are required to meet certain technical requirements including antenna directivity, off axis performance, EIRP limits and power levels at the GSO arc in order to minimize interference to adjacent GSO systems. This sharing orbital arc sharing mechanism provides an efficient way for utilizing the orbital arc and spectrum while providing sufficient system flexibility to GSO FSS operators,

The Commission's 2-degree spacing policy is based on the management of noise temperature among GSO **FSS** systems sharing the same spectrum. This concept is based on the premise that the noise temperature of **a** system **is** subject to increase as the level of interfering emissions from other systems increases. It is, therefore, applied irrespective of the modulation characteristics. Additionally, the ITU has relied on this concept for administrations, including the US administration, to follow to determine the potential for interference among GSO networks. Specifically, the ratio of the apparent increase in the equivalent satellite **link** noise temperature resulting from interfering emissions to the equivalent satellite link noise temperature (?T/T) is determined. If the ratio exceeds 6 percent, **as** determined by the ITU, then there exist the potential for interference and coordination is required between the GSO FSS systems. The equivalent satellite link noise temperature is referred at the output of the receiving antenna. For **a** bent pipe transponder (non-processing transponder) system the analysis encompasses both the uplink and downlink noise contributions. For a baseband transponder (signal processing transponder) system each portion of the link (ie. uplink and downlink) is treated independently. This ?T/T approach to satellite coordination is made possible through grouping FSS systems with similar technical characteristics in the same service allocation.

Very Small Aperture Terminals (VSATs). In 1986 the Commission established rules for the licensing of very small aperture (VSAT) satellite earth stations in the 12/14 GHz bands.[96] Since then, VSAT operations have been widely deployed across the United States. VSAT systems are private networks that use a large main antenna to communicate by satellite link to **a** large number of smaller remote earth stations. The hub station controls **all** remote transmissions. The Commission provided for "blanket" licensing of VSATs by creating an exclusive allocation for the GSO FSS and VSAT operations, The FSS allocations that are used for VSAT operations have no terrestrial operations in them and, therefore, coordination among the operations is not necessary This **has** led to much technical flexibility and growh in the service. The Ku-band **FSS** satellite networks are used for voice, data, facsimile and video transmission, satellite control signals and, also, broadcasting to consumers in what is called the "Direct-to-

[96] ***In the Matter of Routine Licensing of Large Networks of Small Antenna Earth Stations Operating in the 12/14 GHz Frequency Bands,*** Declaratory Ruling (rel. **April** 9, 1986) (VSAT Order). The I I.7-12.2 GHz Ku-band Fixed Satellite Service (FSS) downlink **is** associated with **uplink** spectrum at 14.0 14.5 GHz.

Home"[97] (DTH) GSO/Fixed Satellite Service. This should not he confused with the BSS described below. The allocations are now used to provide internet and video services directly to end users via smaller antennas than originally envisioned that are more marketable to consumers.

Broadcasting Satellite* Service *(BSS). In the 1980's, satellite technology advanced to the point where the direct to home Broadcast Satellite Services (BSS) could become a reality. The member states of the ITU realized that the ability to broadcast to the people of their countries could he extremely important and, in-order to ensure that all countries had access to this service, ordered the ITU to draft a technical plan whereby every administration could receive BSS TV services. The BSS plans took into account the requirements of all of the member states and, based upon assumed technical parameters and agreed upon interference allotments, attempted to fulfill everyone's BSS requirements. The ITU first developed a BSS plan for Regions 1 and 3[98]. Later, a Region 2[99] plan was devebped that included the **US** requirements. In the ITU Region 2 the BSS Plan used 12.2 – 12.7 GHz for the satellite-to-user frequency band. At the same time the ITU recommended that the 12.2-12.7 GHz band be cleared of the existing fixed services because it was expected that fixed service systems would give interference to the ubiquitously deployed home BSS receivers. The exclusive BSS allocation allows satellite systems to share the spectrum through a geographic and orbital separation allotment plan that provides administrations access to particular orbital slots and channels in the plan. By limiting the operating constraints to inter-system sharing, U.S. BSS networks have adapted to the plan and use higher powered satellites to serve small antennas (i.e. smaller than 1.2 m VSAT antennas) that have much less gain but are more marketable to consumers.

Mobile Satellite Service (MSS). Exclusive spectrum and exclusive frequency assignments within the spectrum have been made by the Commission to provide for the implementation of MSS systems. In order to use omnidirectional antennas on the mobile satellite handsets, frequency separation among the satellite systems is necessary. Separate frequency assignments allow for higher power satellites to deliver signals to handsets with low antenna gain (e.g. omnidirectional antennas) and higher gain antennas on the satellites to receive weaker signals from the handsets. Like PCS and other emerging technologies, the exclusive MSS frequency assignments allow for smaller, less power consuming end user equipment that is marketable to consumers. The size of the mobile earth terminals (METs) must be small enough to have consumer acceptance. This could not be accomplished by PCS or MSS with directional antennas on the mobile terminals. The frequency and geographic isolation tradeoff in order to implement these services, therefore, leads to exclusive spectrum for the services whereby the systems have technically similar and compatible characteristics and the constraints are lmited to intra service sharing of the spectrum. Specifically, the Commission has allocated the 1525-

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[97] DTH-FSS originated in **the** 4/6 GHz, Gband frequencies **and** was later deployed in the Ku-band frequencies. Millions of home subscribers still receive programming **in these** frequency bands.
[98] ITU-R Region 1 is comprised of Europe, Russia and Africa. ITUR Region 3 **is** comprised of Asia and Australia.
[99] ITU-R Region 2 comprises North and South America.

1559 MHz/1626.5-1660.5 MHz (Lband), 1610-1626.5 MHz/2483.5-2500 MHz (Big LEO band), and 1990-2025 MHz and 2165-2200 MHz (2 GHz MSS) bands for MSS system implementation.

***L-band** MSS.* The Lband allocation was made by the Commission in 1986 and it concluded that, because of the difficulties in sharing the spectrum, the spectrum available in the Lband could support only one U.S. space station licensee. Currently, that U.S. MSS system is operating in portions of the Lband spectrum. Spectrum sharing problems arose because of the combined use of regional coverage antennas on the L-Band satellites and near-omni-directional antennas on the user terminals. The use of near omni-directional antenna was required to reduce the size of the user terminal but the lack of antenna discrimination prevented the isolation among the different L-Band MSS systems thereby reducing the total number of systems that could be implemented in the spectrum. For tbese same reasons, L-band MSS systems do not share the Lband service allocation with other services.

Big LEO MSS. The 1992 World Administrative Radio Conference (WARC-92) allocated the 1610-1626.5 MHz band on a co-primary basis with other satellite services for MSS operations in the Earth-to-space direction. WARC-92 also allocated the 2483.5 2500 MHz band on a co-primary basis for MSS operations in the spaceto-Earth direction (the "Big LEO' hands). On a secondary basis, WARC-92 further allocated the 1613.8 1626.5 MHz band for MSS operations in the spaceto-Earth direction. In 1994, the Commission allocated exclusive spectrum (with the exception of Radioastronomy in the 1610.6-1613.8 MHz band) and issued service rules for Big LEO MSS. Furthermore, the Commission designated the 1621.35-1626.5 MHz band exclusively to time division multiple access/frequency division multiple access (TDMA/FDMA) operations and the 1610-1621.35 MHz and 2483.5-2500 MHz bands for code division multiple access (CDMA) operations because of the inability of CDMA systems and TDMA/FDMA systems to share the same frequencies. Nonetheless, these constraints were intra-service related and were much less constraining on the deployment of the two MSS systems in operation today than inter-service constraints may have been on these systems.

2 *GHz MSS.* WRC-92 also allocated 1980-2010 MHz and 2170-2200 MHz bands to MSS on a global basis. Additionally, WRC-95 adjusted the allocations to include the 2010-2025 MHz and 2160-2170 MHz bands for MSS in ITU Region 2, effective January 1, 2005 in the United States and Canada effective January 1, 2000. In 1997, the Commission allocated the 1990-2025 MHz (uplink) and 2165-2200 MHz (downlink) bands to MSS in United States, it adopted 2 GHz MSS service rules in August, 2000, and issued MSS licenses in June, 2001. The 2 GHz MSS allocations are shared with terrestrial systems, however, and exclusive MSS use of the allocations is premised on the MSS licensees, according to service rule requirements, relocating the incumbent terrestrial systems.

Fixed Satellite Service (FSS) - Non-Geostationary Fixed Satellite Service (NGSO/ FSS) sharing. Service allocations typically do not distinguish among the different service delivery options available to the operators.[100] In the 1990s, a variation in the use of the FSS spectrum was initiated. It was proposed that constellations of Non-Geostationary (NGSO) satellites in the Ku-band frequencies (11 and 12 GHz band downlink, 14 GHz tand uplink), under certain conditions, could share the same spectrum with the GSO FSS and the DBS systems. These systems now have international and domestic allocations in the 11.7-12.7 GHz range. NGSO FSS systems had a high potential to cause unacceptable interference to operational and planned GSO FSS systems. Initial sharing proposals from the NGSO community were based on non operation of NGSO systems within a defined orbital separation from the GSO arc. This was intended to limit the potential for h-line event interference. The initial proposals indicated that the NGSO systems could share without impact on the GSO networks and that the GSO networks would not be aware of the NGSO systems operations. However, the potential interference increases with the implementation of additional NGSO systems.

Previously, the GSO FSS interference environment was defined by the characteristics of the particular satellite networks in the GSO arc (GSO satellite sharing was based on orbital position, knowledge of antenna directivity and off axis gain characteristics, as well as power density levels – See earlier discussion of ?T/T). Now after more than 6 years of technical studies, a sharing solution was reached that provides for NGSO system operations without overly constraining incumbent GSO FSS systems![101] The solution defined for the GSO community an aggregate interference that could be designed around by their future systems to accepj the anticipated level of interference. Furthermore, the GSO FSS would have to Emit its antenna off axis EIRP levels for future networks. The NGSO community as a result has a defined interference environment that is produced by the operational GSO FSS systems that it can design around.

Constraints were placed on the GSO FSS operations (and FS operations in the shared allocations) in the Ku-bands in the U.S. in order to increase in spectrum utilization within the FSS by NGSO systems. The price paid to maximize the use of the "white space" in the spectrum was that the incumbent GSO FSS operations (and terrestrial system operations in the shared bands) are more constrained in that they must take measures to protect the NGSO systems and accept more interfering power from them. The flexibility lost by the GSO FSS is that a possible reduction in antenna size or use of higher power levels in the future (which may be needed for higher level modulation to support new applications) were sacrificed to accommodate the new use of the FSS and FS allocations. The interactions between GSO and NGSO systems are being further considered in higher frequency bands such as 20/30 GHz (Ka-band) and 30/40 GHz (V-band).

[100] The service allocation is technology neutral. For **example,** the allocation does not limit the frequency band to a particular modulation or orbital altitude.

[101] The sharing criteria resulted in limits to aggregate **and** single entry Equivalent Power Flux Density (EPFD) both in the uplink and downlink directions from the NGSO systems. This was a defined value which represents the combined radiation levels from the NGSO systems into any GSO receive antenna either at an Earth station **or** satellite.

Shared Use of Service Allocations

The Gband and Ku-band Fixed Satellite and Fixed Service Allocations. It is possible, too, for various services to share the same spectrum when their technical characteristics are different but compatible. For instance, in the United States, the 416 GHz spectrum (C-band) and 11/14 GHz spectrum (Ku-band) is allocated on a co-primary basis to the terrestrial Fixed Service (FS) and the Fixed-Satellite Service (FSS). Since 1974, thousands of terrestrial microwave stations and satellite earth stations have been coordinated and licensed by the Commission in the Gband alone. Within the FS, the bands are used for both commercial and private microwave communications. In the FSS, the **4** GHz and 11 GHz portions of the Gband and Ku-band are used for space-to-Earth (downlink) applications including direct-to-home video programming. The 6 GHz and 14 GHz portions of the bands are used for Earth-to-space (uplink) communications. International allocations are similar to the U.S. allocations. The stations of the two services use directional antennas which can be coordinated to use the same frequency assignments through geographic separation. Both services continue to coordinate the use of the "white space" in the Gband and Ku-band to maximize the use of the frequencies. Indeed, the service rules for FS and FSS systems in the shared frequency bands require advanced (prior to license application) frequency coordination between the fixed earth stations and microwave stations. The constraints are limited, however, to those that are necessary to complete the coordination of the systems (i.e. the constraints placed on the stations are limited to those necessary to resolve mutually unacceptable interference and the constraints may be more or less for different stations).

More recently, the Commission has adopted service rules and a licensing approach for G band Small Aperture Terminals (CSATs). CSATs are similar to Ku-band VSATs (described earlier) in that they consist of networks of smaller remote earth stations that communicate via satellite to a large main antenna or hub. The hub station controls all remote transmissions. Because the Gband is used heavily by the Fixed Service, unlike the exclusive Ku-band FSS allocations for VSATs, technical constraints and coordination procedures were placed on CSAT operations. CSATs are limited to a portion of the shared allocation and to communications over a limited number of satellites. By adopting these limits, a streamlined licensing approach was made possible for CSAT licensees to more readily deploy networks of **CSAT** remote antennas while protecting the FS from unacceptable interference and preserving the Gband for future terrestrial FS growth.

Ku-band BSS, NGSO FSS and FS sharing. Use among systems in a shared allocation will become more and more constrained as system requirements call for complex sharing arrangements for all of the allocated services to have access to the spectrum. As more services are delivered directly to end users (the users can be anywhere in the geographic service area and the user density in the geographic area **is** high) the demand for uncoordinated access to the spectrum increases for ubiquitous deployment of systems. Furthermore, the licensing method used for ubiquitous terrestrial services authorizes the service provider on an 'area wide' basis the flexibility to install systems within a given geographic area. Any interference generated within the system is under control of the single operating entity. By the same token, ubiquitous space services that meet certain criteria can he provided 'blanket' licenses where the criteria applied to the space system prevents interference from occurring and allows the earth terminals to be placed at any location within the satellite service area. If transmitters of one system are randomly placed among the receivers of another system through widearea or blanket licensing, interference will occur. Therefore, sharing between two ubiquitous services in the same geographic areas is, in general, not feasible.

Furthermore, it is costly for ubiquitous services to have constraints on the placement of terminals because of the needed ability to serve customers that may be anywhere within the licensed geographic service area. Operating constraints such as transmitter power or placement limit the operators' flexibility to provide true ubiquitous service. For example, the Direct Broadcast Service (DBS) **is** a BSS service in the U.S. which **is** ubiquitous. Geostationary (GSO) DBS satellites deliver broadcast signals to users through out the U.S. The DBS receivers all use high gain antennas that generally point in a southerly direction and can be located anywhere in the country. The NGSO/FSS proposed to take advantage of these operating characteristics and limit the interference power that it would produce at a DBS receiver from a constellation of satellites delivering broadband data in the same frequency band. This sharing situation results in power constraints on the NGSO/FSS and an increase in the interference normally received by a DBS user.

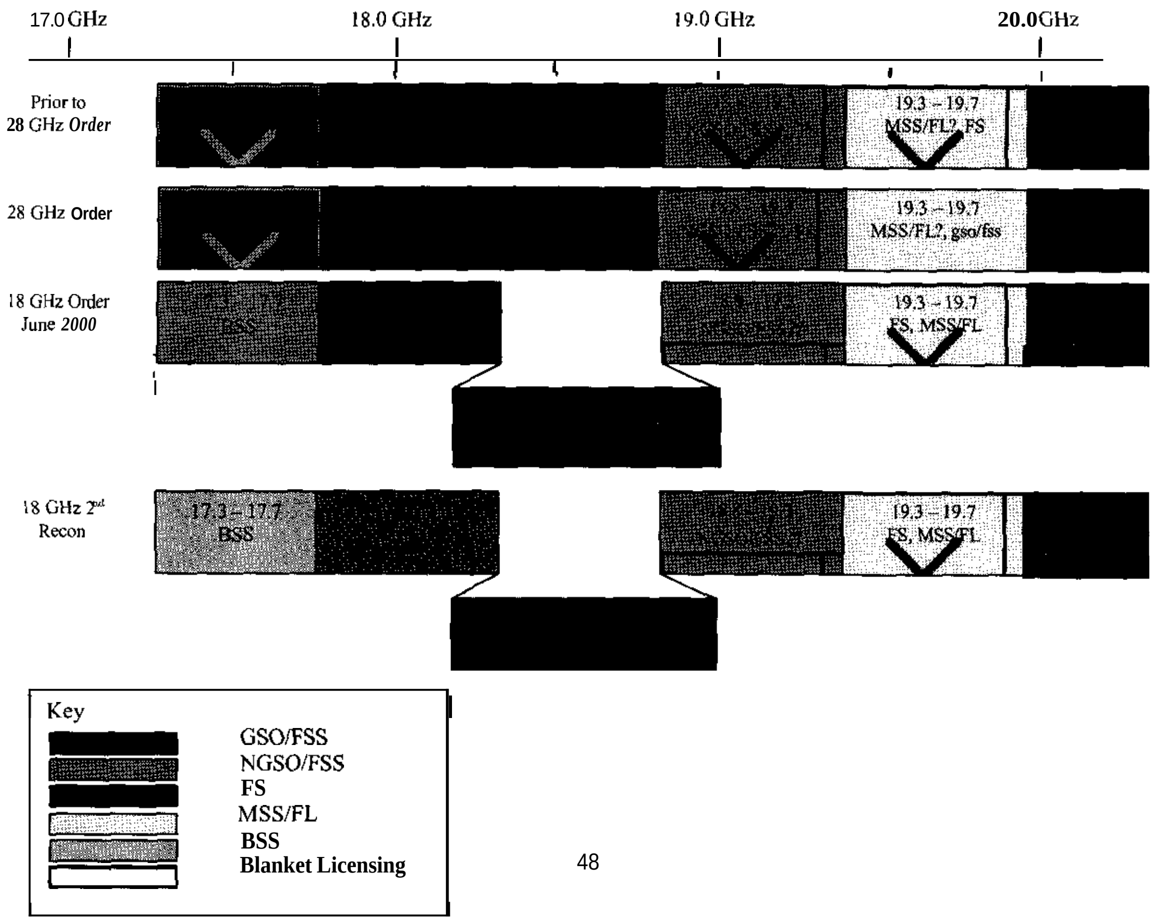
Recently, another service, MVDDS, proposed to operate in the FSS and BSS frequmcy bands. MVDDS is a terrestrial point-to-multipoint service. In this case, the Commission adopted rules that will permit the three ubiquitous services to exist in the same band by placing constraints on the MVDDS transmitters and defining areas where NGSO/FSS stations are not permitted to operate. It also adopted a "first-in" arrangement whereby the MVDDS operator must not operate within 10 km of an NGSO receiver and the NGSO operator must accept interference from preexisting MVDDS transmitters. Additionally, the MVDDS operator must notify the NGSO operator of the location of the MVDDS transmitters so that the NGSO operators can avoid them. In sum, the introduction of MVDDS resulted in power constraints on the MVDDS to protect both the DBS and NGSO FSS systems, the possible exclusion of the NGSO/FSS from areas near an MVDDS antenna, and DBS receivers will need to accept additional interference.

In general, the tradeoff for introducing more services into an allocation is to limit some of the technical flexihilities of all the systems in the allocation. As the sharing situation becomes more complex, more constraints must be placed on newly introduced services and on the existing services as well. Wide-area and blanket licensing is also constrained due to the need to accommodate the "first-in" stations of the other service. At this stage, the services are no longer truly ubiquitous.

Sharing possibilities in the Ku-band among ubiquitous services have been explored hut in the Ka-band and V-band, the Commission has taken a different approach. The approach has led to fewer technical and regulatory constraints on the services hut the cost associated with the flexibility to have blanket licensing and wide area licensing comes at the price of exclusive service allocations. In the Ka-band and V-band, it is proposed that ubiquitous point to multipoint services with small antennas with little or no sidelobe attenuation would have highly dense deployment of transmitters and receivers. **If** both services are to operate in same frequency hand, many more constraints on both services would have to he in place to avoid mutually unacceptable interference. **An** alternative would he to allocate spectrum exclusively to each of the particular services and limit constraints to intra-service operations. This provides certainty to licensee and provides for more technical flexibility within the service.

Ku-band FSS and FS sharing. From 1997 to the present,' the Commission has modified the frequency allocations and developed service rules (including rules for relocation of incumbent systems) throughout the **17-20** GHz range of frequencies. The allocation changes and service rules adopted by the Commission define the sharing possibilities among the various satellite services and terrestrial services. The following figure shows how the service allocations have changed in recent years.

The main reason for the band arrangement is that both the satellite and the fixed services had requirements for ubiquitous deployment of end-user stations. There **is** great difficulty in having two truly ubiquitous services sharing the same spectrum as discussed earlier. In this case the ubiquitous services included the BSS, NGSO/FSS and GSO/FSS. The FSS proposed to provide service to businesses and households from low-orbit and geostationary satellites. The FS allocation is mainly used to provide wireless cable distribution. The BSS proposals are to transmit to the satellites from feeder-link earth stations and downlink to ubiquitous home receivers in the 17.3-17.7 GHz band.



The amount of spectrum that is shared among the terrestrial and satellite services has been significantly reduced. By separating the band into allocations to services that have similar technical characteristics, blanket licensing and widearea licensing for the FSS and FS, respectively, is made possible for the services over most of the spectrum.[102] This permits the service operators to deploy user terminals without having to coordinate with each other. This can only be done without interference constraints relating to inter-service sharing (i.e. in bands free of other services). This required the Commission to adopt rules for relocation of incumbent systems at the expense of the new system operators.

V-band FSS and FS sharing. Prior to 1994, most of the millimeter wave technology in the V-hand was funded by the U.S. Government **for** military and scientific purposes. There was little commercial use of the band, but as technology has evolved, the Commission has initiated several proceedings to make portions of the V-band available for commercial use. Proposals for new technologies increased the demand for spectrum allocations in the 36-51 GHz band and led to complicated spectrum sharing arrangements. The Commission proceedings addressed the potential interference problems between terrestrial wireless systems and satellite services recognizing the limited possibilities of high-density terrestrial wireless systems and high-density satellite systems sharing the same frequency hands.

The Commission recognized, too, that sharing between services intended for cotnmunications with ubiquitous consumer terminals, would likely result in undue technical constraints on one or both of the services. These technical constraints would not permit terrestrial fixed wireless systems (FS) or FSS to achieve their full potentials **After** several years of domestic proceedings and World Radiocommunication Conferences (WRCs), the Cotnmission released a Further Notice of Proposed Rulemaking in May 2001 that proposes to redesignate portions of the V-hand spectrum for FS and FSS, and it creates and shifts allocations of the services. The proposed changes reflect the "soft segmentation approach" developed by the U.S. delegation to the WRC-2000 and adopted by the WRC-2000. The "soft-segmentation" sharing arrangement was also incorporated in the International Radio Regulations. The **soft** segmentation approach generally favors wireless services in the spectrum helow 40 GHz and favors satellite services in the spectrum above 40 GHz **by** requiring more stringent satellite power limits in the spectrum helow 40 GHz. The U S . is attempting ***to*** harmonize its spectrum allocations with the international and regional allocations in order to promote crosshorder arrangements that would enhance the delivery of all V-band services to consumers.

[102] The MSS/FL allocation from 19.3-19.7 GHz does not involve ubiquitous services and therefore sharing with the FS is possible. Mobile satellite service Feeder-links **only** involve a few earth stations that use large, highly directive, antennas. These earth **stations** can share **with** the **FS** via standard a frequency coordination approach and wide **FS** station deployment is still possible.